U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-258 759-T

Investigation of Dispersion of Pollutants in the Vicinity of Tall Emission Sources

Environmental Protection Agency, Research Triangle Park, N C

1971

300028

PB 258 759-T
EPA-TR-647-73 D
APTIC 46907

INVESTIGATION OF DISPERSION OF POLLUTANTS IN THE VICINITY OF TALL EMISSION SOURCES

[Issledovaniye rasprostraneniya vrednykh primesey v rayone vysokikh istochnikov vybrosa]

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Atmospheric diffusion and air pollution
1971, pp. 82 - 86

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NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

Translated for EPA by
SCITRAN (SCIENTIFIC TRANSLATION SERVICE)
SANTA BARBARA, CALIFORNIA

BIBLIOGRAPHIC DATA SHEET	1. Report No. EPA TR73-6470	2.	3. Recipient's Accession No.
4. Title and Subtitle: Investigation of dispersion of pollutants in the vicinity of tall emission sources			5. Report Date: 1971 6.
7. Author(s): V.A. Belugina, N.S. Buremin, P.I. Velikaya, B.B. Goroshko			8. Performing Organization Rept. No.
9. Performing Organization Name and Address: TRANSLATED FROM RUSSIAN BY EPA			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address: EPAISD, Translations Section, Research Triangle Park, N.C. 27711			13. Type of Report & Period Covered 14.

15. Supplementary Notes: ATMOSPHERIC DIFFUSION AND AIR POLLUTION 1971, pp.82-86

16. Abstracts

17. Key Words and Document Analysis. 17a. Descriptors: EPAISD

17b. Identifiers/Open-Ended Terms: AIR POLLUTION - SOURCES

17c. COSATI Field/Group: 13B 68A

PRICES SUBJECT TO CHANGE

18. Availability Statement: THIS TRANSLATION WAS MADE FROM A NON-COPYRIGHTED TEXT.	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 10
	20. Security Class (This Page) UNCLASSIFIED	22. Price $3.50

INVESTIGATION OF DISPERSION OF POLLUTANTS IN THE VICINITY OF TALL EMISSION SOURCES

V.A. Belugina, N.S. Burenin, P.I. Velikaya and B.B. Goroshko

The Main Geophysical Observatory imeni A.I. Voyeykov has conducted experimental work in the vicinity of thermal electric power stations with an emission height of 120 m (Shchinskiy and Cherepet State Regional Power Plant) and 180 m (Moldavian State Regional Power Plant) [5, 6, 7, 9]. The data obtained made it possible to check the agreement of theoretical work in calculating the field of concentrations conducted under the leadership of M. Ye. Berlyand [2. 3, 10] with experimental data. The comparison which was made revealed a satisfactory agreement of the results. A method was then worked out for calculating the field of ceoncentration of dust and sulfur dioxide from industrial enterprises [1, 10].

It is very important to check the method of calculation for higher sources, since the emission at many state regional power plants now passes through 250 m stacks, and still taller stacks are planned for the future. Hence, the problem consisted in obtaining experimental data on the field of concentration in the vicinity of state regional power plants with an emission height of 250 m. The Krivorog State Regional Power Plant No. 2 was selected to solve this problem; this power station has two stacks 250 m tall and one stack 180 m tall. The work was conducted from June to July 1970 by members of the Ukrainian Expeditionary Branch of the MGO.

The work program provided for gradient observations of the speed and wind direction as well as the temperature and atmospheric humidity at the

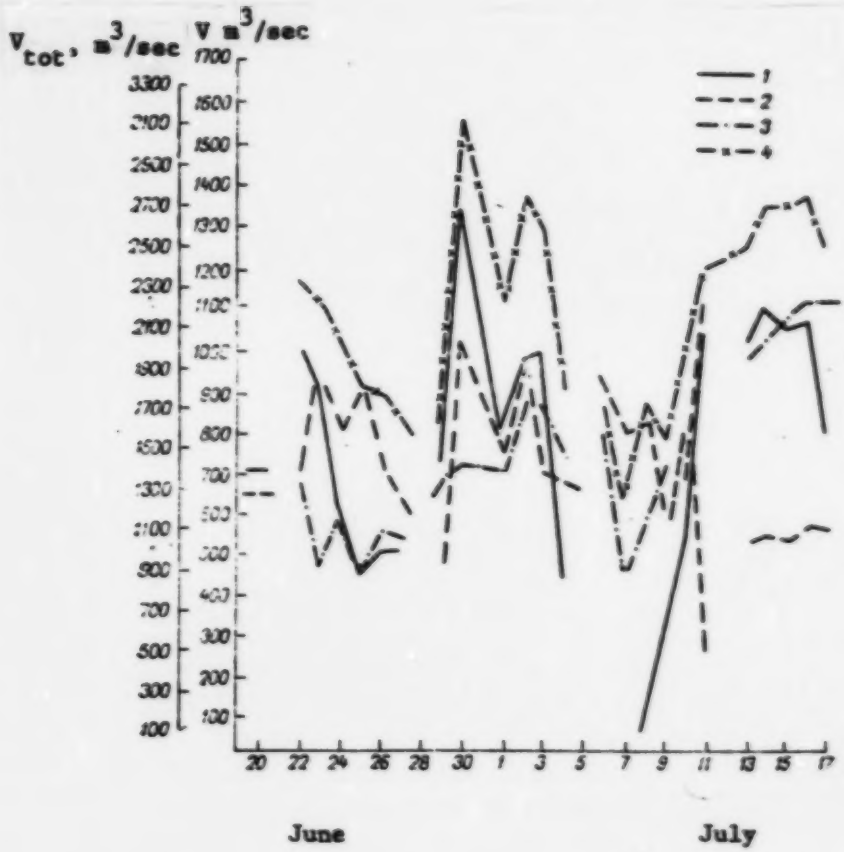

Figure 1. Variation in the volume of smoke gases emitted from the stacks of the State Regional Power Plant.

1 - stack height 180 m; 2 and 3 - stack height 250 m; 4 - total emission from three stacks.

0.5 and 2.0 m levels. The field of concentration was measured beneath the plume of the state regional power plant at five to six distances simultaneously, with periodic replacement of the latter by the following distances from the source: 1, 2, 3, 4, 5, 6, 7, 8, 10 and 15 kilometers. Sampling took place in the morning, daytime, and evening hours in order to cover different meteorological conditions. A significant fact relating to the work was that for the first time not only sulfur dioxide and dust were sampled, but nitrous oxides and carbon monoxide as well. The principal ingredients, sulfur dioxide and dust, were collected in two parallel samples. The sample analysis was performed in accordance with methods adopted by the Hydrometeorological Service system.

Directly at the electrical power station itself, the total volume of gas emitted from each stack; the temperature of this gas, and the amount of sulfur dioxide and dust emitted into the atmosphere per unit time were determined. Samples were collected in the flues behind the filters and subsequently subjected to chemical analysis for sulfur dioxide and nitrous oxide.

During the period of the tests, the source operated in an unstable fashion, i.e., the volume of emitted gases varied within wide limits. This is clear from Figure 1, which shows a change in the volume of gases emitted into the atmosphere for each stack and the total volume for all the stacks. At the same time, there were changes in the emission of harmful substances. Therefore, in calculating the concentration field only the maximum emission values at the state regional power plant were taken into account, since they made it possible to determine the most dangerous atmospheric pollution conditions. The concentrations measured beneath the plume were analyzed according to a method suggested by M. Ye. Berlyand [8], consisting in the fact that all of the concentrations obtained at the same wind speed are plotted on the graph and an envelope is plotted for the maximum values.

TABLE 1

Ingredient	Data	Distance from the source (km)						
		1	2	3	5	7	10	15
Dust	Calculated	0.3	0.7	0.9	1.0	0.7	0.6	0.4
	Experimental	0.5	0.8	0.9	1.0	0.9	0.8	0.7
Sulphur dioxide	Calculated	0.4	0.7	0.9	1.0	0.9	0.7	0.5
	Experimental	0.6	0.7	0.9	1.0	0.9	0.7	0.6

The calculation of the concentration field was conducted in accordance with the "Guidelines for Calculating Dispersion of Pollutants in the Atmosphere (Dust and Sulfur Dioxide), Contained in the Emissions from Industrial Enterprises" [10].

The graphs plotted for the distribution of concentrations as a function of distance from the source on the basis of experimental and calculated data show that their values coincide satisfactorily. This can be seen in Table 1, where the values taken from the graph show the relationship of the maximum concentrations of dust and sulfur dioxide for a number of distances from the source to the maximum concentration at 5 km (q/q_{max}).

It should be pointed out that the actual concentrations are somewhat higher than the calculated ones. This difference is 7% at the maximum. This lack of agreement is completely natural if we take into account the errors in determining the fuel consumption, and chemical analysis of the fuel and samples. Individual values for maximum concentrations did turn out to be higher than the envelopes. Percentagewise, they make up an insignificant part of the total amount of collected samples. 1.4% of the samples at 1-4 km were above the experimental curve, 1% at 10-15 km, 0.03% at the maximum. A slightly greater difference is observed at short distances, which is explained by the influence of low (from 30 meter stacks) and unorganized emissions (gas flues, coal piles, etc.). They were not taken into account in the calculation. The effect of the influence of unorganized emissions decreases with increasing distance from the source and reaches minimum values with the calculated concentrations at the maximum.

To a lesser degree, there is agreement between the calculated and the actual concentrations with respect to dust content. At the maximum, these differences make up 20% and increase with increasing distance. Here, however, it is necessary to take the fact into account that the weight method of determination does not exclude the fall of natural dust which may significantly increase the concentration. The possibility of error in the accepted value for the operation of electrical filters with an efficiency of 95% cannot be excluded, since the electrical filters had not been changed for a long time and there is a possibility that the efficiency of the filters used in the calculations was significantly overestimated. These factors led to an increase in the values of the measured concentrations in comparison with the calculated ones.

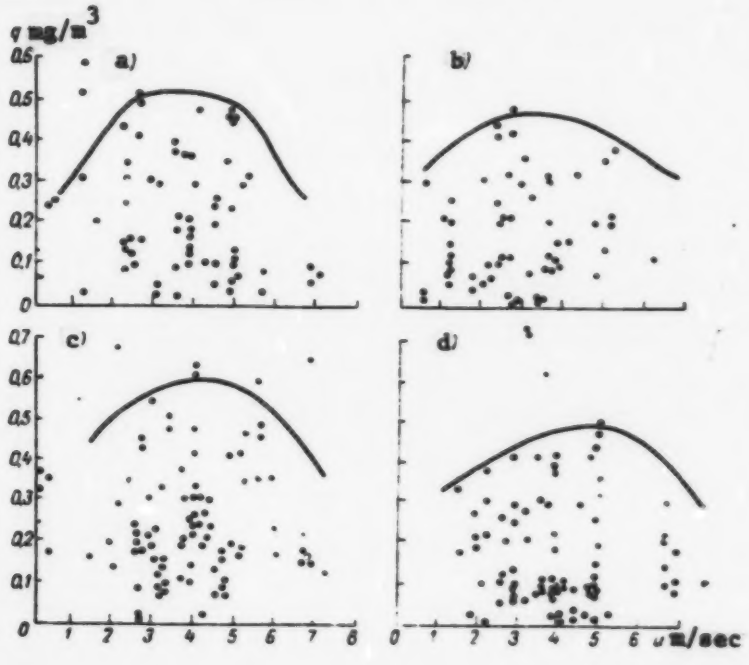

Figure 2. Distribution of concentrations of sulphur dioxide as a function of wind speed at various distances from the source of the emission.
a - 1 km; b - 3 km; c - 5 km; d - 8 km.

Figure 2 shows the distribution of the concentrations as a function of the wind speed at distances of 1, 3, 5 and 8 km. The wind speed is relative to the height of the wind vane (h_v = 10 m) in accordance with the measurement data at an altitude of 2 meters with consideration of the logarithmic distribution. It follows from the figures that the concentration increases with increasing wind speed, reaching a maximum value and then decreasing. Hence, there is a certain dangerous speed u_M at which the maximum concentrations are found. In the case of the source in question, according to Figure 2, u_M = 4-5 m/sec. The dangerous speed is calculated according to the formula

$$u_M = 0{,}65 \sqrt[3]{\frac{V \Delta T}{H}},$$

where V is the volume of the gas-air mixture which is emitted (m^3/sec), ΔT is the difference between the temperature of the emitted gas-air mixture and the temperature of the ambient atmospheric air; H is the height of the emission source. Calculations according to the formula given above yielded u_M = 5 m/sec.

Hence, there is a satisfactory agreement between the experimentally determined, and the calculated values for the dangerous wind speed.

These measurements of the concentrations of nitrous oxides were the first to be conducted in the vicinity of a state regional power plant. An analysis of the samples showed that nitrous oxides are contained in the emitted gases. Their maximum concentrations are approximately seven times less than the concentration of sulfur dioxide.

REFERENCES

1. The Time Method of Calculating Dispersion of Emissions in the Atmosphere (Ash and Sulfur Dioxide) from the Smokestacks of Electrical Power Stations. Trudy GGO, No. 172, pp. 205-212, 1965.

2. Berlyand, M. Ye. et al. Numberical Investigation of Atmospheric Diffusion Under Normal and Abnormal Stratification Conditions. Trudy GGO, No. 158, pp. 22-32, 1964.

3. Berlyand, M. Ye., Ye. L. Genikhovich and R. I. Onikul. Calculating Pollution of the Atmosphere by Emissions from Smokestacks of Electrical Power Stations. Trudy GGO, Vol. 158, pp. 3-21, 1964.

4. Berlyand, M. Ye. and R. I. Onikul. Physical Bases for Calculating the Dispersion of Industrial Emissions in the Atmosphere. Trudy GGO, No. 234, pp. 3-27, 1968.

5. Gil'denskiol'd, R. S. et al. Results of Experimental Studies of Atmospheric Pollution in the Vicinity of the Moldavian State Regional Power Plant. Trudy GGO, No. 207, pp. 65-68, 1968.

6. Goroshko, V. B. Performance of Experimental Work Involving the Study of the Propagation of Pollutants from Large Sources. Trudy GGO, No. 234, pp. 109-115, 1968.

7. Goroshko, V. B. et al. Meteorological Observations in the Investigation of Industrial Pollution of the Layer of Air Near the Ground. Trudy GGO, No. 138, pp. 18-30, 1963.

8. Onikul, R. I. et al. Results of an Analysis of Experimental Data Characterizing the Distribution of Atmospheric Pollutants Near Thermal Electrical Power Stations. Trudy GGO No. 172, pp. 23-34, 1965.

9. Rikhter, B. V., R. S. Gil'denskiol'd and V. M. Styazhkin. Distribution of Sulfur Dioxide and Ash Concentrations Near the Ground in the Vicinity of a Thermal Electric Power Station. Trudy GGO, No. 158, pp. 84-87, 1964.

10. Ukazaniya po Raschetu Rasseivaniya v Atmosfere Vrednykh Veshchestv (Pyli i Sernistogo Gaza), Soderzhashchikhsya v Vybrosakh Promyshlennyh Predpriyatiy (Guidelines for Calculating Dispersion of Harmful Substances in the Atmosphere (Dust and Sulfur Dioxide), Contained in the Emissions From Industrial Enterprises). State Standard 369-67. Leningrad, Gidrometeoizdat, 1967.